

Recent Progress in Satellite Data Assimilated 4D Global Precipitation Products

From the GEOS System

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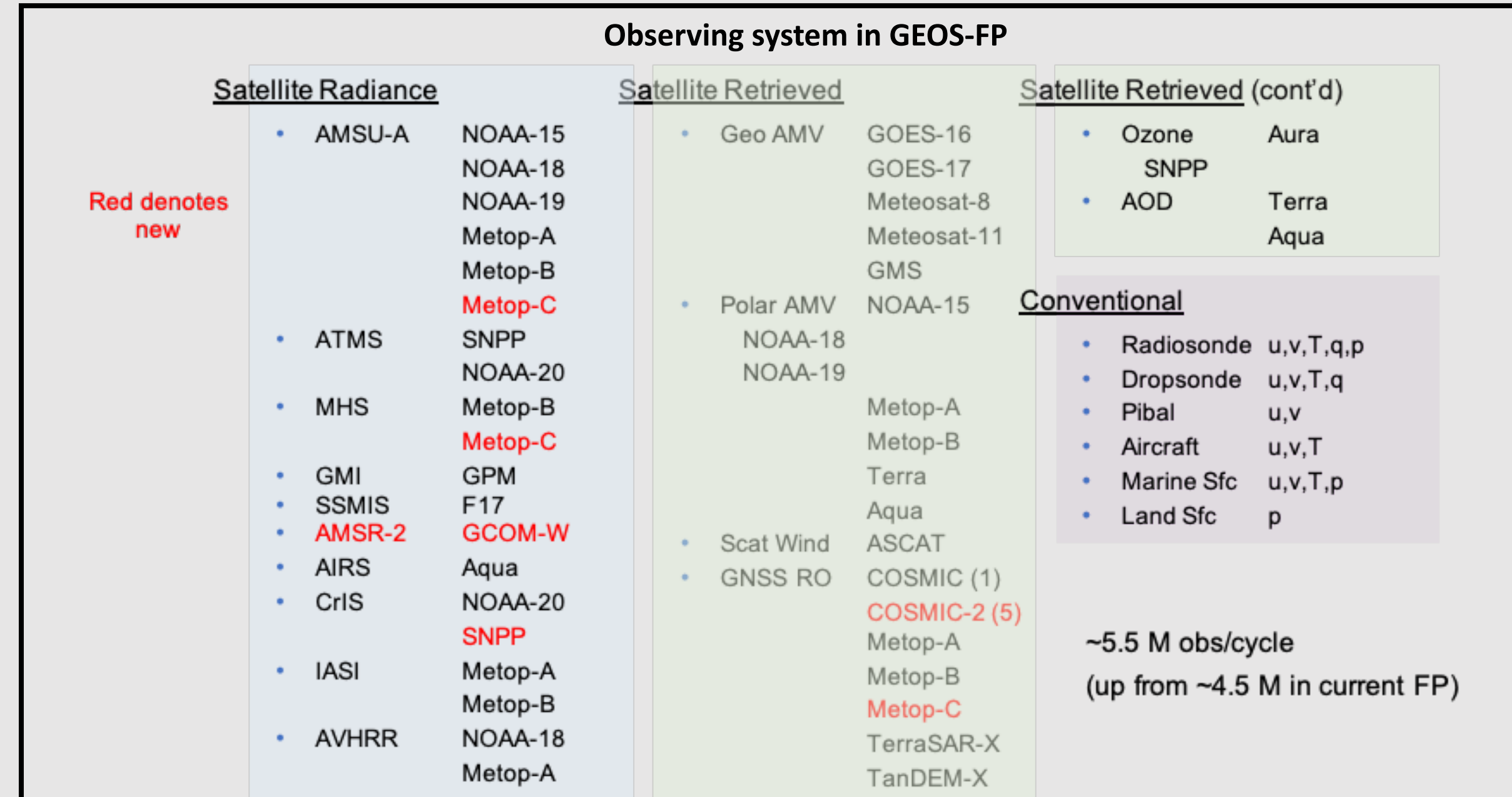
GMAO

Global Modeling & Assimilation Office



Goddard Earth Observing System (GEOS)

GEOS is the main system that is used for applications across a wide range of spatial scales, from kilometers to many tens of kilometers. The system consists of a group of model components such as Atmospheric General Circulation Model (AGCM), Ocean General Circulation Model (OGCM), Chemistry-Climate Model (CCM), Chemistry Transport Model (CTM), etc.



Extending All-sky System to Other Microwave Data for GEOS-FP upgrades and next NASA reanalysis

To maximize the benefits, the all-sky system is being adapted to **assimilate more data from other microwave sensors** such as AMSR2/GCOM-W, Microwave Humidity Sounder (MHS), Advanced Microwave Sounding Unit (AMSU-A), Advanced Technology Microwave Sounders (ATMS), and Special Sensor Microwave Imager/Sounder (SSMIS), and Sounding for Probing Vertical Profiles of Humidity (SAPHIR).

Status of all-sky MW data assimilation developments in						
Satellite	Sensor (Scanner)	# of Channels (Frequency)	Clear sky		Cloudy/Precipitating sky	
			Ocean sfc	Non-Ocean	Ocean sfc	Non-Ocean
GPM	GMI (conical)	13 channels (10GHz~190GHz)	★	★	★	★
GCOM-W1	AMSR-2 (conical)	7 channels (6.9 GHz ~ 89 GHz)	★		★	
DMSP F16, F17, and F18	SSMIS (conical)	24 channels (19.35 GHz ~ 190GHz)	●★	●★	★	★
NOAA-18 & 19, METOP-A & B	MHS (cross-track)	5 channels (89GHz ~ 190GHz)	●★	●★	★	★
NOAA-18 & 19, METOP-A & B	AMSU-A (cross-track)	11 channels (23.8 GHz ~ 89 GHz)	●★	★	★	★
SNPP, NOAA-20	ATMS (cross-track)	22 channels (23.8 GHz ~ 190GHz)	●★	★	★	★
Megha-Tropiques	SAPHIR	6 channels (183.2 GHz ~ 194.3GHz)	★	★	★	★

● Clear-sky assimilated in GEOS-FP

★ All-sky data assimilated in GEOS-FP

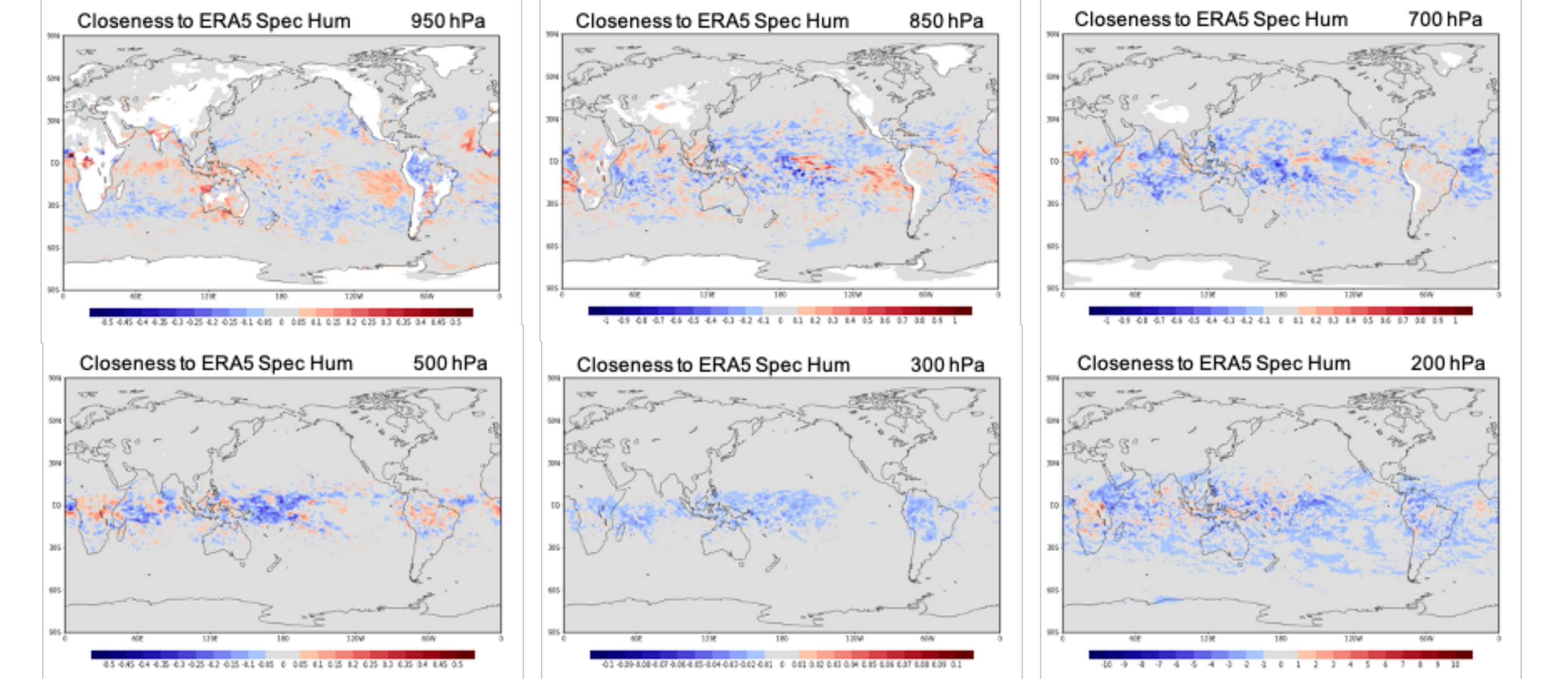
★ Development getting matured.

★ To be implement in GEOS-FP later this year

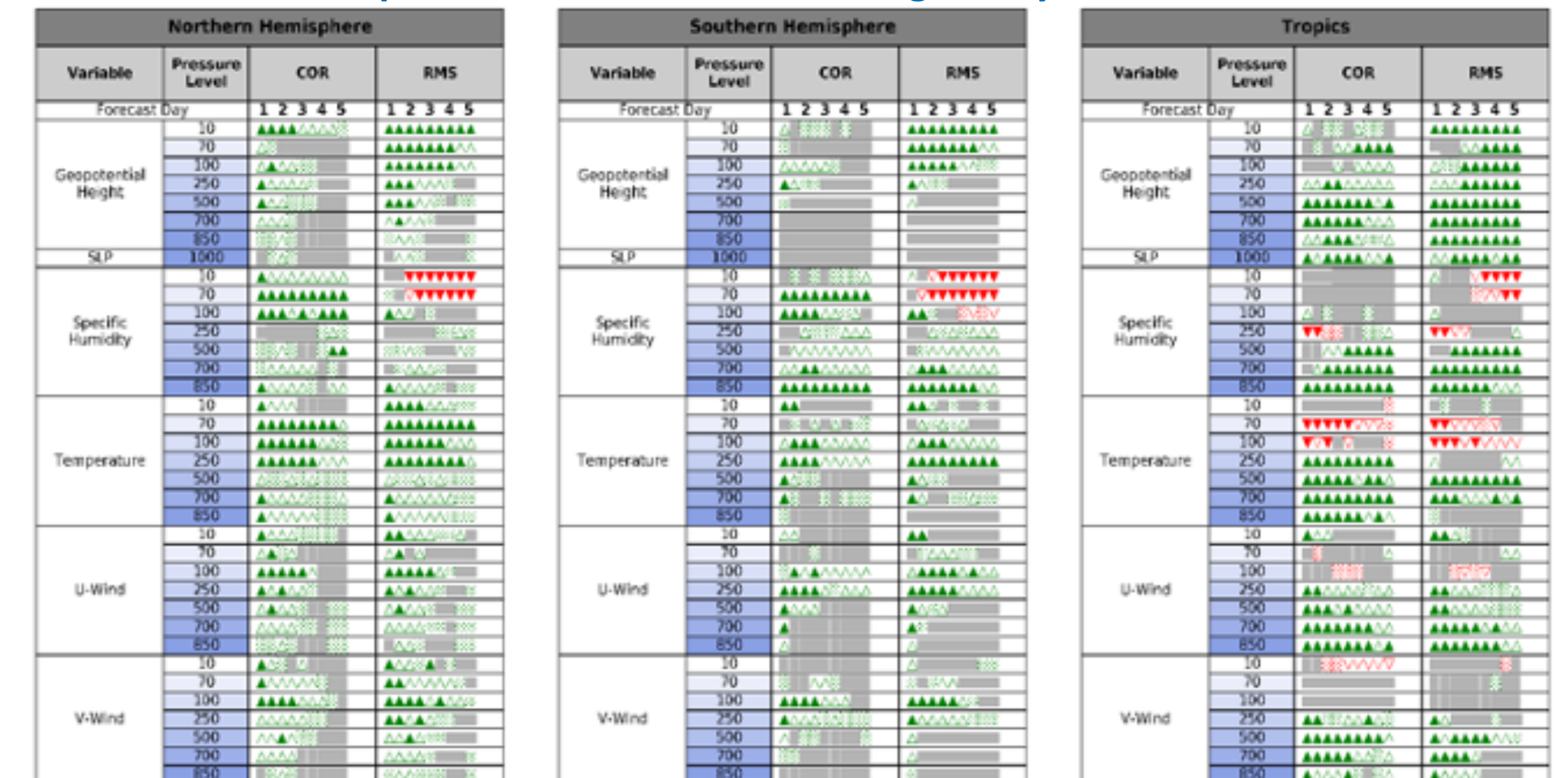
★ Development has just started.

Closeness to ERA5 vs. operational control: specific humidity (g/kg)

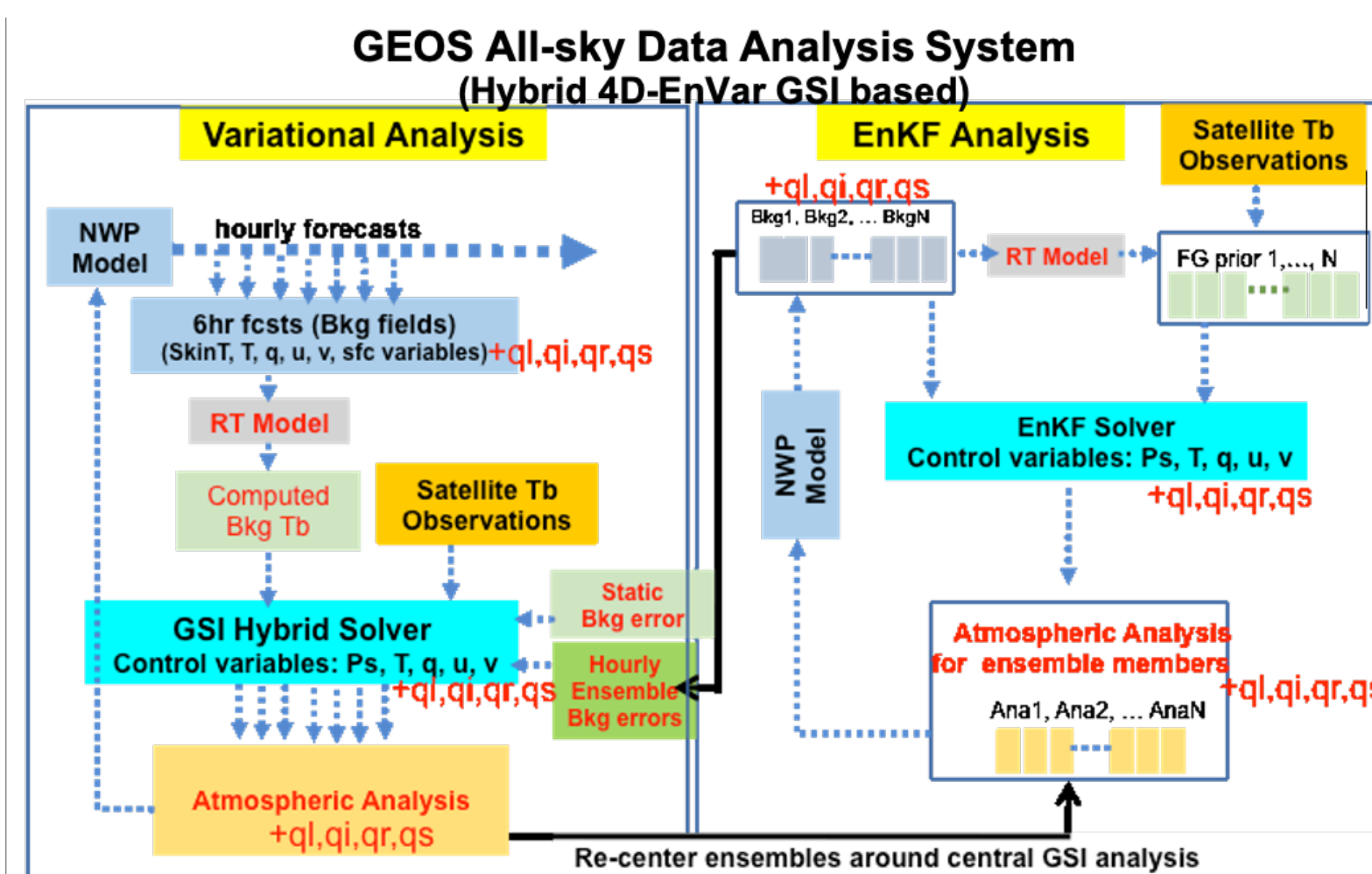
01Dec~31Jan 2019/20 All-sky MHS/AMSR2+COSMIC2 GEOS vs. Current GEOS (blue: All-sky MHS/AMSR2+COSMIC2 GEOS closer to ERA5)



Forecast Skill Improvements of GEOS including all-sky GMI, MHS, and AMSR2



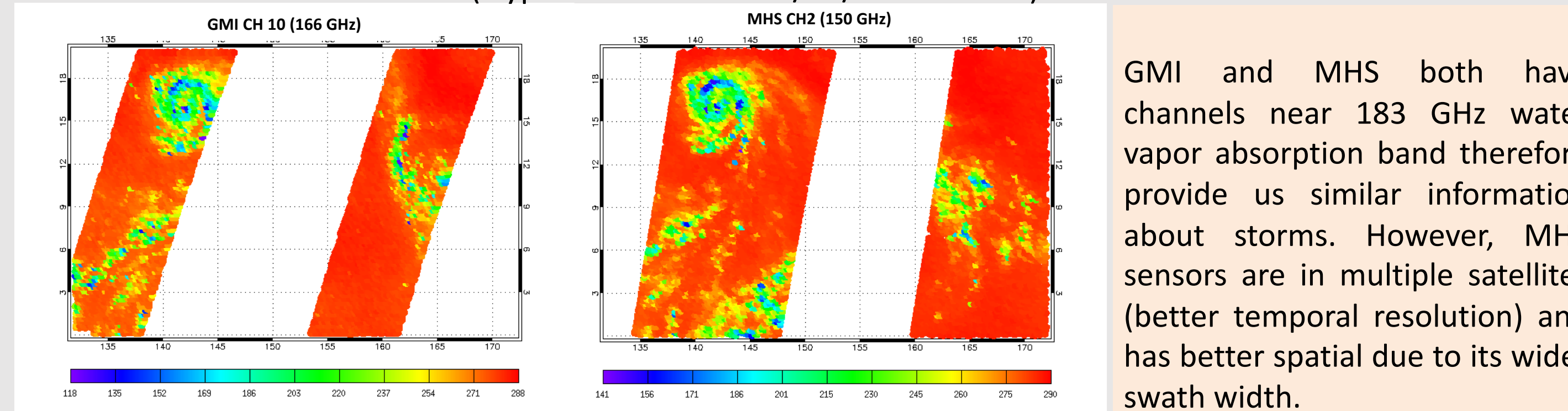
GEOS Atmospheric Data Assimilation System



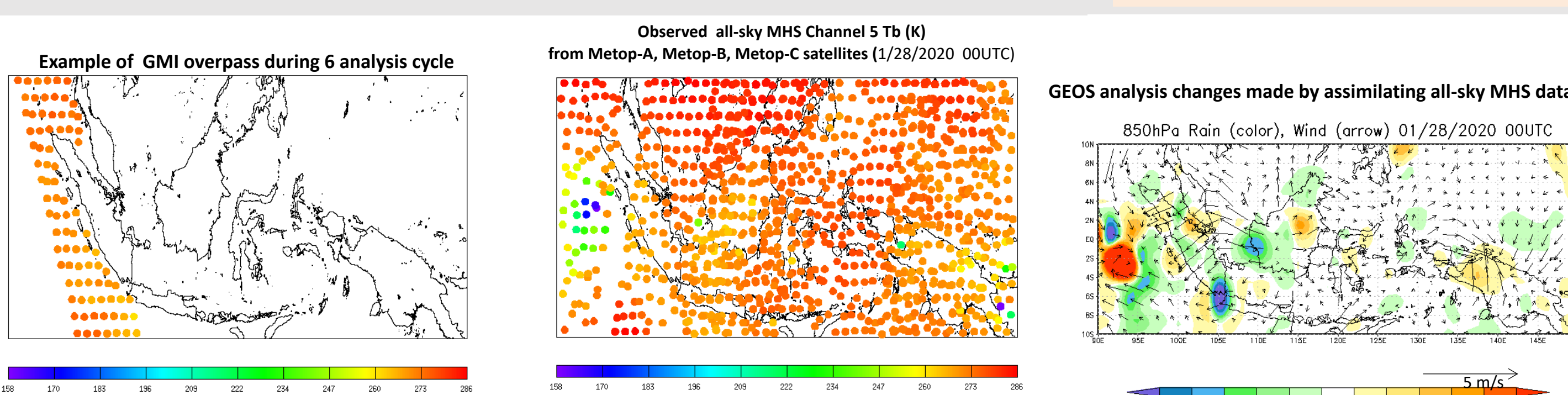
- Significant changes were made in GEOS to assimilate cloud and precipitation affected radiance data (Kim et al. 2020, MWR).
- Four new state and analysis control variables were added for hydrometeors (liquid cloud, ice cloud, rain, and snow)
- Background error for these hydrometeors are generated and used.
- Observation error models (symmetric error model, Geer and Bauer 2011) were built and tuned.
- Bias correction and quality control procedures for all-sky microwave radiance data were developed.
- Enhanced radiance observation operator, Community Radiative Transfer Model (CRTM)

Comparisons of Observed All-sky Brightness Temperatures

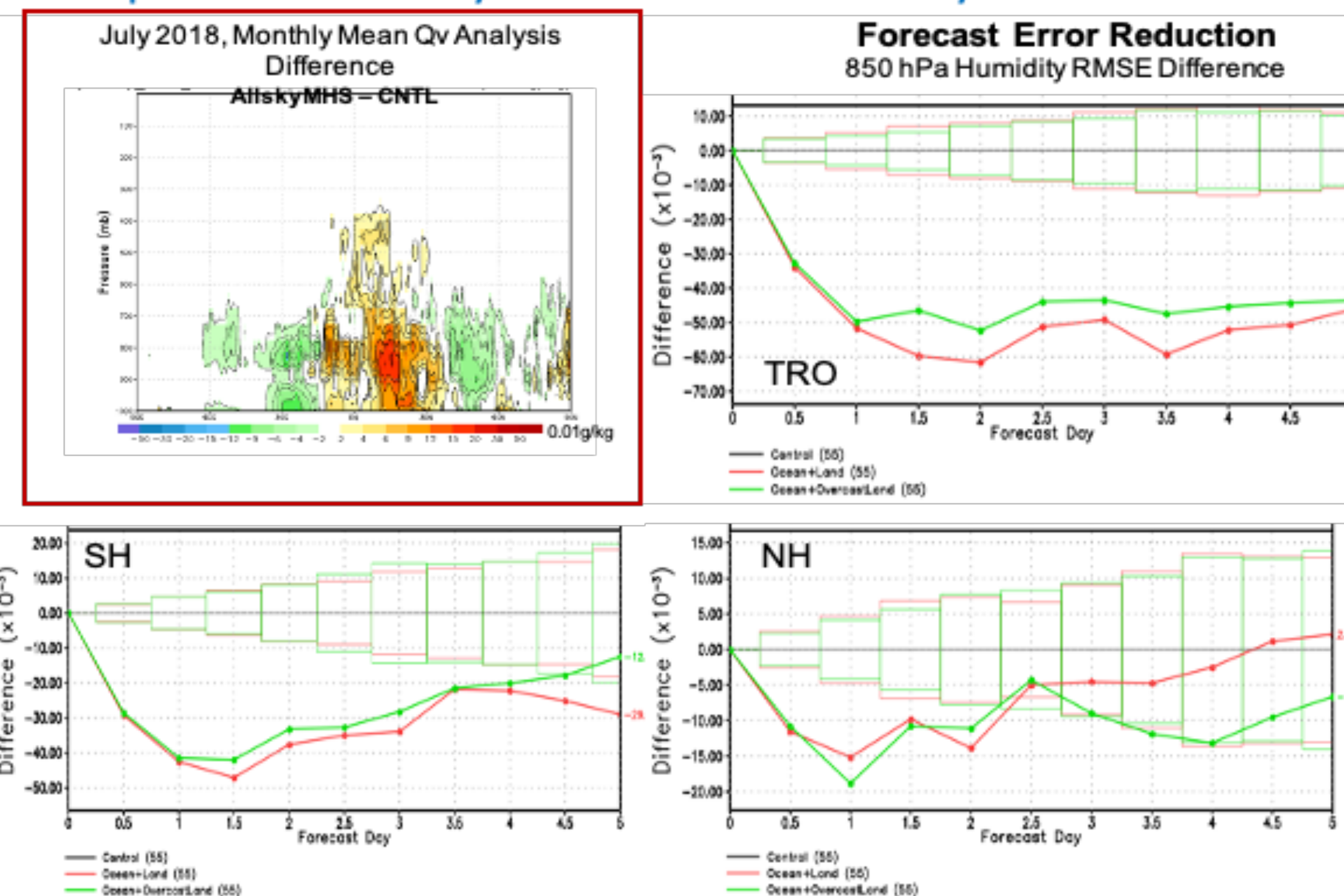
(Typhoon Maria 2018/07/06 0000UTC)



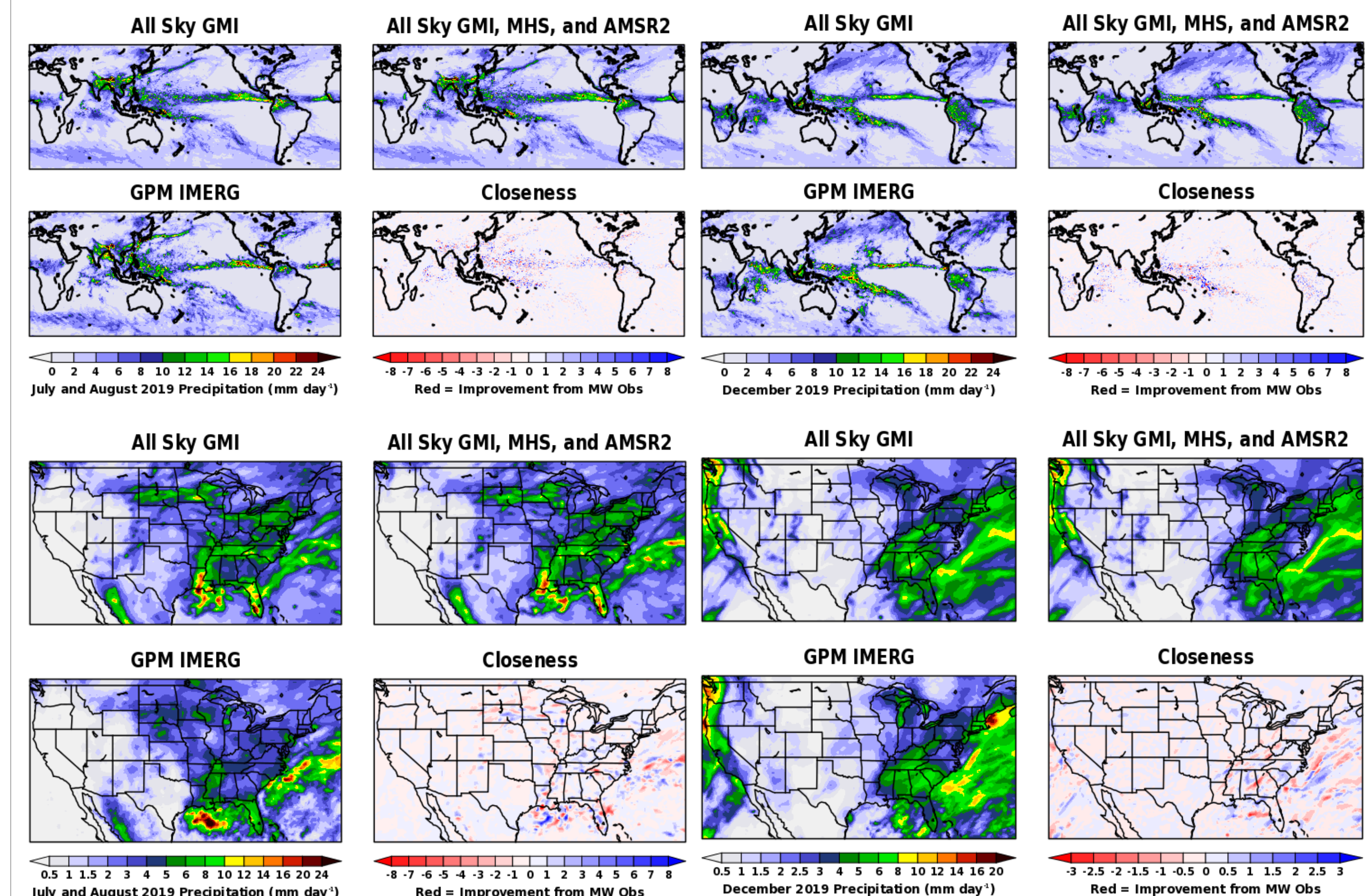
GMI and MHS both have channels near 183 GHz water vapor absorption band therefore provide us similar information about storms. However, MHS sensors are in multiple satellites (better temporal resolution) and has better spatial due to its wider swath width.



Impact of MHS all-sky radiances on GEOS analyses and forecasts



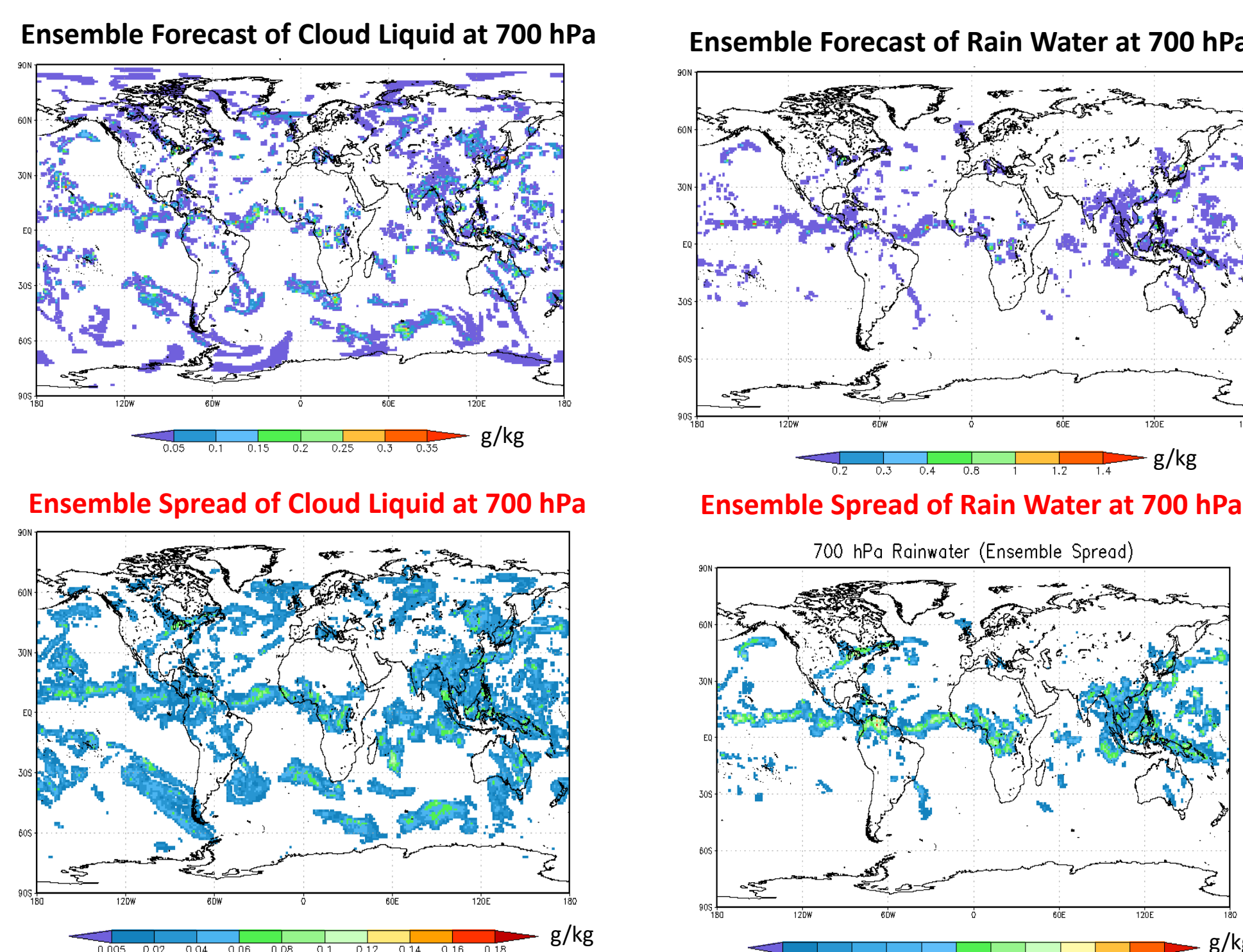
Comparisons of GEOS Precipitation Analysis Product and IMERG



Work in progress

- Delivering 1-year long GEOS precipitation analysis products from the next GEOS-FP system assimilating all-sky GMI, MHS, and AMSR-2 (possibly available to PMM Science Team by late2020/early 2021)
- Developing precipitation analysis products from GEOS assimilating all-sky ATMS, SSMIS, and AMSUA
- Developing GEOS Downscaling precipitation analysis products (7km) for 2015/12-2016/01 (OLYMPEx period).

Background Errors for Moisture Variables from 32 GEOS Ensemble Forecasts



What cloud and precipitation affected Tb data do on GEOS analyses?

Case study: Hurricane Gaston (2016)

